Morphological Characters and Proximate Composition of Crab, *Callinectesamnicola* from Tropical Marine Environment

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Abstract:
The study investigated the growth patterns, sex ratios, mean condition factor and proximate composition of the body fluid of male and female blue crab, Callinectes amnicola from tropical marine habitat. This is with a view to providing information for effective management of C. amnicola as a fish resource. One hundred and ninety-five (195) crabs were purchased on landing at the Akodo Marine Beach in Ibeju-Lekki Local Government Area, Lagos State, Nigeria.
The length-weight relationships and the Condition factor were determined. Growth was a negative allometry in C. amnicola with females exhibiting a comparatively better growth pattern. A total of 87 males and 108 females were encountered, given sex ratio of 0.8 male: 1 female. There was no significant difference between male and female sex ratios (t = -1.219; P= 0.310; df = 3) from the expected and hypothetical 1 male: 1 female ratio. The moisture content was higher than other nutritional contents recorded in the body fluid of C. amnicola.
In conclusion, C. amnicola demonstrated favourable growth patterns and minimal variation in sex ratio. C. amnicola contains sufficient nutrients and minerals that are beneficial to humans as food and in farmed animal nutrition.

Keywords: Length-weight relationships, growth patterns, condition factor, Akodo marine beach

1. Introduction

There are approximately 4,500 know species of crab worldwide (Sternberg & Cumberlidge, 2001). Crabs inhabit almost all marine environments around the world from the coast to the deep sea and from polar waters to the tropics (Boschi, 2000).

Callinectes amnicola is a famous blue crab of the family Portunidae. It is one of the most abundant and economically important swimming crabs inhabiting the brackish lagoons and marine environment in Nigeria, where it is a key resource in local fisheries. The species is generally a cherished source of protein and minerals in human diet and animal feeds (Emmanuel, 2008; Muse *et al.*, 2017).

Crabs remain one of the least exploited crustaceans in artisanal and trawler fisheries in West Africa. In this region, the target species in shellfisheries are prawns and shrimps that have high export potential (Ajana, 1996; Awosika *etal.*,2002).

Owing to underutilization of crabs as a resource, resulting in a paucity of information on crabs from Nigerian continental shelf, the study aims to determine the relative growth and proximate composition of body fluid of *Callinectesamnicola* collected from the Akodo marine beach.

2. Materials and Methods

2.1. Study Area

Akodo beach is located in Ibeju-Lekki Local Government Area of Lagos state. It lies between latitude 06° 25'50" N - 06° 26' 30" N and longitude 003°55'30" E – 003° 56' 00" E. Akodo is a coastal fishing community characterised by artisanal fishermen.

2.2. Collection of Specimens

Crabs used in this study were purchased monthly from artisanal fishermen in Akodo beach, between August and November 2015. Procured crabs were transported to the laboratory of Department of Zoology, Obafemi Awolowo

University, Ile-Ife in a Cool box packed with ice. The crabs were identified based on the method described by Schneider (1992). In all, 195 crab specimens (*Callinectes amnicola*) were examined. All of the crabs used were in good condition, with the carapace intact and unbroken.

2.3. Morphometric Measurement

In the laboratory, using the digital vernier calliper, the Carapace Length (CL), Carapace Width (CW), Right Chelae Length (RCL), Left Chelae Length (LCL), Abdominal Width (AW) and Abdominal Length (AL) were determined to the nearest 0.01mm while the Body Weight (BW) was measured using Scout Pro® (SPU 202) weighing balance to the nearest 0.01g. Equations expressing the length/width - weight relationships of C. amnicola were calculated in relation to sex using the linear regression routine of Microsoft Office® Excel (2016).The Fulton's condition factor (K) was calculated according to Bagenal (1978).

2.4. Sex Ratio

C. amnicola were sorted according to sex using the method described by Sachs and Cumberlidge (1991); the shape and size of the abdomen distinguish the sexes.

2.5. Proximate Analysis

Crab body fluid was obtained by breaking the carapace using the dissecting set. Proximate composition of body fluid was carried out according to the standard procedure of the Association of Official Analytical Chemist (AOAC, 2005). Moisture content was determined by drying the sample in an oven (Uniscope SM9053) at 102 - 105 °C and dried to constant weight. Ash content was determined by incineration of 5 g of the sample at 600 °C in a muffle furnace (Carbolite AAF1100) for 8 hours. Determination of crude fat content was by Soxhlet extraction method using n-hexane as solvent. Nitrogen content was determined using the Kjeldahl method and the quantity of protein was calculated by multiplying the percentage nitrogen content by the conversion factor 6.25 as described by Pearson (1976).
IBM SPSS® (version 22) and Microsoft Office® Excel 2016 were employed for the statistical analyses.

3. Results

3.1. Morphometry

A total of 195 *Callinectes amnicola* crabs of both sexes (87 males and 108 females) were collected from Akodo beach and were analysed. The various morphometric characters are summarised in Table 1 below.

3.2. Relationship between Different Morphometric Characters

Allometric equations with respect to male and female *C. amnicola* are shown in Tables 2 and 3. The allometric relations between the set of characters studied revealed that the relationships were positive and highly significant (Figures 1-12).

3.3. Carapace Length and Carapace Width Relationship

There was significant correlation between carapace length and carapace width in male *C. amnicola* (r = 0.80, t = 12.15, P≤ 0.001) and in female (r = 0.52, t = 10.40, P≤ 0.001) (Figure 1).

3.4. Right Chelae and Left Chelae Relationship

There was significant correlation between right chelae length and left chelae length in male(r = 0.63, t = 7.53, P ≤ 0.001) but moderate correlation in female *C. amnicola* (r = 0.32, t = 4.37, P ≤ 0.001) (Figure 2).

3.5. Abdominal Length and Abdominal Width Relationship

A strong positive correlation was recorded between abdominal length and abdominal width in male (r = 0.70, t = 14.79, P ≤ 0.001) and female (r = 0.52, t = 14.61, P ≤ 0.001) *C. amnicola* (Figure 3).

3.6 Right Chelae Length and Swimming Pad Length Relationship

Correlation coefficient (r) between right chelae length and swimming pad length was strongly positive and significant in male (r = 0.70, t = 9.01, P ≤ 0.001) and female (r = 0.58, t = 7.24, P ≤ 0.001) *C. amnicola*(Figure 4).

3.7. Eye Length and Abdominal Length Relationship

The correlation coefficient was strong positive between abdominal length and abdominal width in male *C.amnicola* (r = 0.72, t = 9.42, P ≤ 0.001) while a moderate positive correlation was recorded between eye length and abdominal width in female *C. amnicola* (r = 0.39, t = 4.35, P ≤ 0.001) (Figure 5).

3.8. Antennae Length and Antennule Length Relationship

A strong positive correlation was recorded between antennae length and antennule length in male (r = 0.60, t = 6.99, P ≤ 0.001) while female recorded a very weak correlation between antennae length and antennule length (r = 0.21, t = 1.46, P ≤ 0.001) (Figure 6).

3.9. Carapace Width and Abdominal Width Relationship

The correlation coefficient (r) observed between carapace width and abdominal width in male *C. amnicola* indicated a strong positive correlation (r = 0.77; t = 19.11; P ≤ 0.001). Likewise, female recorded a positive correlation (r = 0.31, t = 11.24; P≤ 0.001) (Figure 7).

3.10. Carapace Width and Abdominal Length Relationship

A strong positive correlation was recorded between carapace width and abdominal length in male (r = 0.84, t = 14.30, P ≤ 0.001) and female (r = 0.58, t = 11.84, P ≤ 0.001) *C. amnicola* (Figure 8).

3.11. Carapace Length and Abdominal Width Relationship

There was a significant correlation between carapace length and abdominal width for male (r = 0.62, t = 9.77, P ≤ 0.001) and female (r = 0.41, t = 10.15, P ≤ 0.001) (Figure 9).

3.12. Carapace Length and Abdominal Length Relationship

Carapace length – Abdominal length showed very strong positive correlation (r = 0.84, t = 14.29; r = 0.75, t = 11.72; P ≤ 0.001) for males and females respectively (Figure 10).

3.13. Carapace Length and Total Weight Relationship

Logarithmic transformation indicated a linear relationship between crab carapace length and body weight measurements. The relationship was expressed as "Log W = Log a + b Log L".
Log W = Log (-2.7289) + 2.7318 Log L .... (r^2 = 0.9182, N = 87) for male
Moreover, Log W = Log (-1.7942) + 2.1130 Log L .... (r^2 = 0.6395, N = 108) for female
(W = Body weight, L = Carapace length, N = Total number of each of male and female crabs examined).
Scatter diagrams were obtained by plotting the log of weight against the log of carapace length for individual crab (Figure 11). From the data presented, a distinct relationship was found between carapace length and total weight, as judged from the closeness of the scatter dots. In males, the growth coefficient or exponential value (b = 2.73) for the carapace length-weight relationship while growth coefficient or exponential value (b = 2.11) in females. This showed that there was a marked deviation from the isometric growth pattern i.e. negative allometry. The regression equations revealed high correlation coefficient values (r = 0.96; r = 0.80) in male and female crabs respectively.

3.14. Carapace Width and Total Body Weight

Logarithmic transformation indicated a linear relationship between crab carapace length and body weight measurements. The relationships are expressed as "Log W = Log a + b Log LW".
Log W = Log (-3.7253) + 2.7395 Log LW .... (r^2 = 0.7628, N = 87) for male
Log W = Log 1.1288 + 0.1486 Log LW .... (r^2 = 0.0441, N = 108) for female
(W = Body weight, LW = Carapace width, N = Total number of each of male and female crabs examined).
Scatter diagrams (Figure 12) were obtained by plotting the log of weight against the log of carapace width for individual crab. A distinct relationship was found between width and total weight, as judged from the closeness of the scatter dots. The growth coefficient or exponential value (b = 2.7395; b = 2.8034) for the carapace width-weight relationship in male and female crabs respectively shows that there is marked a deviation from the isometric growth pattern i.e. negative allometry.

3.15. Condition Factor (K)

Fulton's condition factor (K) is a measure of an individual shellfish's health.
$K = 100(W/L^b)$
Where W is the whole-body wet weight in gramme; L is the length in centimetre; b is the growth coefficient and factor 100 is used to bring K close to a value of 1.
The individual 'K' for the length-weight relationship is shown in (Table 4). The average mean of condition factor for the length-weight relationship and width-weight relationship indicate that the crabs are in a very healthy state in their habitat (k ≥ 1).

3.16. Sex Ratio

In all, 195 specimens were collected among which 87 were males and 108 were females, giving a sex ratio of 0.8 males to 1 female. There was no significant difference between male and female sex ratios, (t = -1.219; P = 0.310; df = 3) (Table 5).

3.17. Proximate Compositions of Body Fluid ofCrabs

The proximate compositions of the body fluid of male and female crabs (*C. amnicola*) from marine habitat near Akodo beach, Lagos are presented in Figures 13 and 14.
Moisture Content: The moisture content percentages were 77.56%, 77.51%, 76.03% and 73.63% in male; and 77.49%, 76.09%, 75.19% and 73.99% in female between August and November respectively. The values decreased from August (rainy season) to November (dry season). It was highest in August and lowest in November for males and females.

Crude Fat: Crude fat component were 13.97%, 14.23%, 14.56% and 16.75% in male; and 14.01%, 14.32%, 15.36% and 16.79% in female between August and November respectively. The values increased from August (rainy season) to November (dry season). It was lowest in August and highest in November. Ash Content: The ash contents were 1.07%, 1.51%, 1.72% and 1.87% in male; and 1.24%, 1.77%, 1.79% and 1.89% in female between August and November respectively. The values increased from August (rainy season) to November (dry season). It was lowest in August and highest in November.

Crude Protein: The percent quantity of Crude protein were 3.70%, 3.88%, 5.12% and 5.63% in male; and 3.26%, 3.72%, 5.44% and 5.88% in female between August and November respectively. The values increased from August (rainy season) to November (dry season). It was lowest in August and highest in November.

Carbohydrate: Carbohydrate contents were 3.50%, 2.81%, 2.57% and 2.12% in male; and 4.00%, 4.10%, 2.22% and 1.85% in female between August and November respectively. The values decreased from August (rainy season) to November (dry season).

4. Discussion

Length and weight relationship is regarded as more suitable for assessing not only fish but also crustacean (Okon & Sikoki, 2014). The relationships between carapace length/width and weight of the crabs have many uses. They are often used to calculate the standing stock biomass, condition indices, analysis of ontogenic changes and several other aspects of crustacean population dynamics (Atar & Secer, 2003). In addition, they are used for the management of the population. According to Lagler (1968), the relationship can be used to estimate the recovery of edible meat crabs of various sizes.

In this study, maximum carapace length recorded was 57.05 mm (34.46 ± 0.44 mm) while Akin-Oriola*et al.*(2005) reported maximum carapace length 60 mm (43.80 ± 0.4 mm) in *Cardiosoma armatum* and 70 mm (51.7 ± 0.4 mm) in *Callinectes pallidus*. The size of the carapace width varies from 37.94 to 118.95 mm (79.24 ± 0.90 mm) and body weight was between 4.81 and 99.14 g (31.71 ± 1.21 g) as reported in the present study. The mean carapace width of males and females were significantly different from each other (P ≤ 0.05). There was also a significant difference in the body weight of males and females (P ≤ 0.05). The carapace width of male is higher than female with a mean value of 82.76mm and 77.06mm respectively but not significantly different, (t = 3.569; P ≤ 0.001; df = 86). The correlation coefficient (r) determined from regression for males and females are 0.7967 and 0.5157 respectively while Mady-Goma*et al.* (2014) reported 0.97 in *Sudanonautes aubryi*.

The linear relationship observed in the present study indicates corresponding increases in carapace length and body weight measurements. The growth patterns of *C. amnicola* indicate negative allometry (b = 2.74 male; b = 2.27 female). Arimoro & Idoro (2007) reported a negative allometric growth in *C. amnicola* from Warri River and Lawal-Are & Kusemiju (2000) on Badagry Lagoon, Nigeria supports this. However, the present study contradicts Akin-Oriola *et al.* (2005) on Ojo Creek and(Oluwatoyin*et al.*,2013) who reported positive allometric growth (b > 3) in their studies. The growth coefficient (b) values have some implications and significant impacts on the well-being of fishes (including shellfish). The negative allometry (b < 3) means the crabs were lighter than their body weights (Lawson & Oloko, 2013). Fish with high growth coefficient (b > 3) are heavy for their weight, while those with low growth coefficient are lighter (Wootton, 1998). The change of growth coefficient (b) values depends primarily on the shape and fatness of the species, seasonal variability of the environment (seasons or time of the years, temperature, salinity) and food availability (quantity, quality and size), sex and stage of maturity (Mommsen, 1998; Henderson, 2005; Ozaydin & Taskavak, 2007). Others factors include sample size and habitat suitability (Morey *et al.*, 2003). The Length-Weight relationship parameters may also vary within the same species due to feeding, reproduction and fishing activities (Bayhan*et al.*, 2008), individual metabolism, sexual maturity and age (Franco-Lopez *et al.*, 2010). The chemical composition analyses of the body fluid of *C. amnicola* revealed variable nutritional contents. The moisture content was higher than other nutritional contents recorded in the body fluid of *C. amnicola*. High moisture content in organisms contributes to the stabilisation of the organisms during movements (Eddy*et al.*, 2004). The crude fat, followed by carbohydrate and crude protein content have relatively low values. The quantity of fat determined in this study is very low. The fat contents confirmed that *C. amnicola* belongs to the low-fat class of meat. Crabs have been reported to show low calories than pork, beef and the poultry (Broughton*et al.*,1997). Female of *C. amnicola* has a higher percentage of fat hence serves as higher food reservoir along with protein. The percentage storage of fat in crabs is subject to periodic fluctuations influenced by environmental variables like temperature (Nagabhushaman & Farooqui, 1982). The presence of the ash content of *C. amnicola* is an indication of mineral concentration in the organism (Eddy *et al.*, 2004; FAO, 2005). The ash contents obtained were very low. The difference in ash content between the sexes can be related to their sizes at the time of collection and seasonal changes of the environment (Fagbuaro*et al.*, 2013). The crude protein reported in the fluid of both male and female C. amnicola are rather low. The protein content of crabs is supported by the sizes at the time of collections, lack of pollution and other environmental factors and food availability. The protein is essential for the sustenance of life (Okuzumi & Fujii, 2000). Percentage carbohydrate available in *C. amnicola* has low value. Although the content of internal tissues was very low, the implication of this is that it will yield a lot of glucose, galactose, fructose and mannose when digested than what could be obtained from consumption of some other organisms (FAO, 2005). These sugars are energy producers in the crabs.

5. Conclusion

This studyprovided information on aspects of the biology of crab, *Callinectes amnicola* for fisheries biology and management, population structure, growth and stock assessment of the species. *C. amnicola* contains sufficient nutrients and minerals that are beneficial to humans as food and farmed animal nutrition, therefore providing a good alternative to consumption of fish species.

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Appendix

Characteristics	Male (N = 87)				Female (N = 108)			
	Minimum Value	Maximum Value	Mean	Std. Error of Mean	Minimum Value	Maximum Value	Mean	Std. Error of Mean
Carapace Width (CW) (mm)	37.94	118.95	82.7635	1.5236	58.82	110.10	77.06	0.6899
Carapace Length (CL) (mm)	19.34	57.05	36.3466	0.8084	23.24	52.90	32.9381	0.4040
Body Weight (BW) (grams)	4.81	99.14	37.7167	2.2190	12.83	95.03	26.8707	1.0548
Right Chelae Length (RCL) (mm)	0.00	112.23	73.9771	2.0509	0.00	101.69	63.2751	1.1580
Left Chelae Length (LCL) (mm)	0.00	98.67	58.3641	3.5881	0.00	257.95	53.1188	3.0422
Swimming Pad (SP) (mm)	21.32	69.10	44.0645	0.9176	29.86	60.28	38.9138	0.4273
Abdominal Length (AL) (mm)	7.85	39.32	22.7613	0.4977	16.55	36.85	21.5920	0.2751
Abdominal Width (AW) (mm)	2.36	34.91	22.4306	0.5367	2.41	37.74	22.5776	0.3409
Eye width (mm)	2.61	9.76	6.0709	0.1432	3.50	8.78	5.5776	0.0881
Antennae (side pair) (mm)	0.00	22.15	11.7294	0.3195	0.00	22.19	10.2032	0.2841
Antennae (middle pair) (mm)	3.28	12.00	8.1853	0.1943	0.00	12.00	7.2227	0.1779

Table 1: Measurements of Morphometric Characters of Male and Female C. amnicola

Independentvariable (X)	Dependent variable (Y)	Allometric Growth Equation (Y = A + Bx)	'R²' VALUE
Carapace Length (CL)	Carapace Width (CW)	CW = 28.188 + 1.5015CL	0.6347
Right Chelae Length (RCL)	Left Chelae Length (LCL)	LCL = -23.516 + 1.1068RCL	0.4002
Abdominal Length (AL)	Abdominal Width (AW)	AW = 5.3075 + 0.7523AL	0.4867
Right Chelae Length (RCL)	Swimming Pad Length (SPL)	SPL = 20.929 + 0.3127RCL	0.4886
Eye Length (EL)	Abdominal Length (AL)	AL = 7.6834 + 2.4836EL	0.5107
Antennae Length (AntL)	Antennules Length (AntuL)	AntuL = 3.8741 + 0.3676AntL	0.3653
Carapace Width (CW)	Abdominal Width (AW)	AW = 0.0392 + 0.2705CW	0.5898
Carapace Width (CW)	Abdominal Length (AL)	AL = 0.0363 + 0.2746CW	0.7065
Carapace Length (CL)	Abdominal Length (AL)	AL = 3.9573 + 0.5174CL	0.7061
Carapace Length (CL)	Body Weight (BW)	BW = -56.351 + 2.5881CL	0.8890
Carapace Width (CW)	Body Weight (BW)	BW = -51.877 + 1.0825CW	0.5525

Table 2: Allometric Equations and R² Values between Morphometric Variables of Male C. amnicola

Independent Variable (x)	Dependent Variable (Y)	Allometric Growth Equation(Y = A + Bx)	'r²' Value
Carapace Length (CL)	Carapace Width (CW)	CW = 34.745 + 1.2647CL	0.2659
Right Chelae Length (RCL)	Left Chelae Length (LCL)	LCL = 0.4752 + 0.8320RCL	0.1003
Abdominal Length (AL)	Abdominal Width (AW)	AW = 8.5997 + 0.6474AL	0.2730
Right Chelae Length (RCL)	Swimming Pad Length (SPL)	SPL = 25.4820 + 0.2123RCL	0.3309
Eye Length (EL)	Abdominal Length (AL)	AL = 14.8180 + 1.2152EL	0.1514
Antennae Length (AntL)	Antennule Length (AntuL)	AntuL = 5.8751 + 0.1321AntL	0.0445
Carapace Width (CW)	Abdominal Width (AW)	AW = 14.357 + 0.1076CW	0.0978
Carapace Width (CW)	Abdominal Length (AL)	AL = 9.2444 + 0.1616CW	0.3388
Carapace Length (CL)	Abdominal Length (AL)	AL = 4.7428 + 0.5115CL	0.5642
Carapace Length (CL)	Body Weight (BW)	BW = -42.982 + 2.1207CL	0.6598
Carapace Width (CW)	Body Weight (BW)	BW = -20.21 + 0.6162CW	0.3351

Table 3: Allometric Equations and R² Values between Morphometric Variables of Female C. amnicola

Sex	Relationship	Minimum 'K' value (gcm⁻³)	Maximum 'K' value (gcm⁻³)	Mean 'K' value (gcm⁻³)
Male	Length – Body weight	58.1052	175.7847	102.1279
	Width – Body weight	2.6248	11.3263	6.2444
Female	Length – Body weight	82.0078	430.7382	211.7721
	Width – Body weight	3.6479	16.2618	8.5362

Table 4: Condition Factor 'K' for the Length/Width – Weight Relationships forMale and Female Callinectes amnicola

Month	Male	Female	Male: Female (Sex Ratio)
August	34	40	0.85:1
September	18	22	0.81:1
October	17	33	0.51:1
November	18	13	1.38:1
Total	87	108	0.89:1

Table 5: Monthly Sex Ratio of Callinectes amnicola
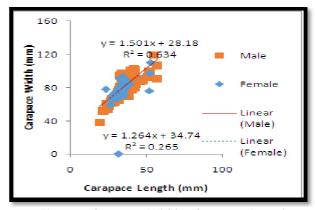
Figure 1: Carapace Width – Carapace Length Relationship inMale and Female Callinectes amnicola
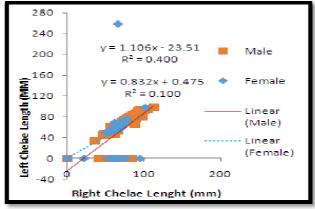
Figure 2: Left Chelae Length – Right Chelae Length Relationship inMale and Female Callinectes amnicola
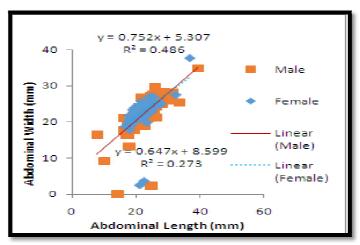
Figure 3: Abdominal Width – Abdominal Length Relationship of Male and Female Callinectes amnicola
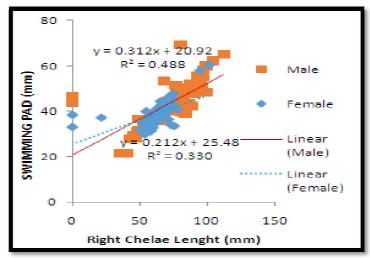

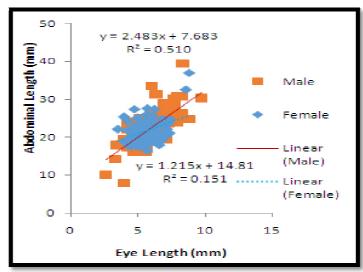*Figure 4: Right Chelae – Swimming Pad Relationship in Male and Female Callinectes amnicola*

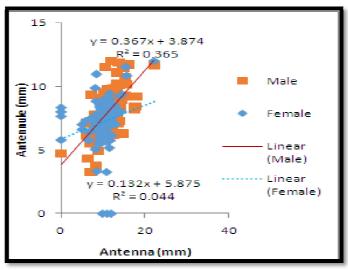*Figure 5: Eye Length – Abdominal Length Relationship in Male and Female Callinectes amnicola*

Figure 6: Antennae Length – Antennule Length Relationship in Male and Female Callinectes amnicola
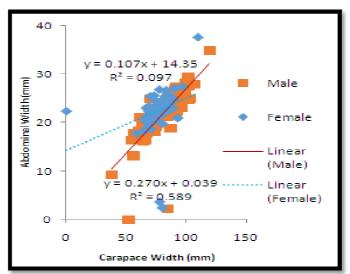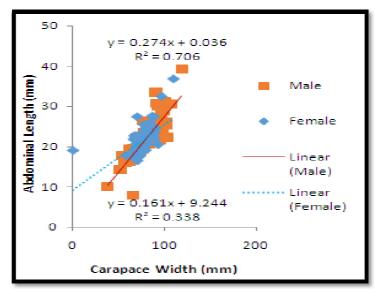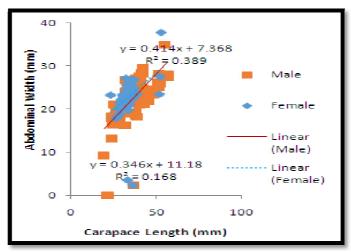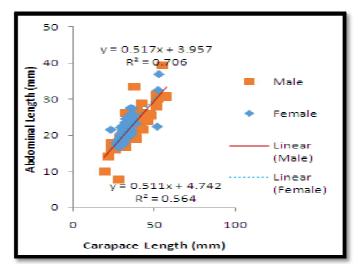

Figure 7: Carapace Width – Abdominal Width Relationship in Male and Female Callinectes amnicola

Figure 8: Carapace Width – Abdominal Length Relationship in Male and Female Callinectes amnicola

Figure 9: Carapace Length – Abdominal Width Relationship in Male and Female Callinectes amnicola

Figure 10: Carapace Length – Abdominal Length Relationship in Male and Female Callinectes amnicola
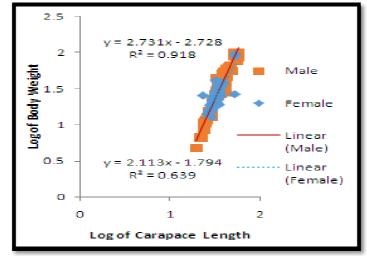
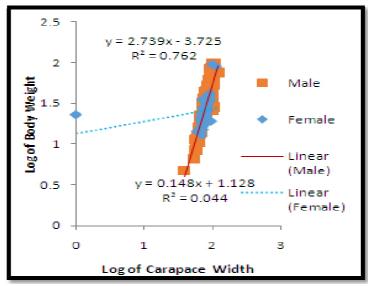*Figure 11: Log of Body Weight against Log of Carapace Length for Male and Female Callinectes amnicola*

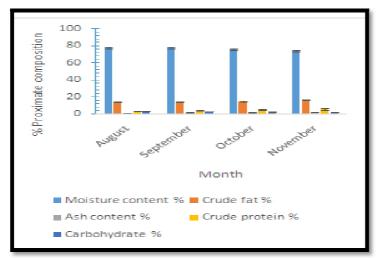*Figure 12: Log of Body Weight against Log of Carapace Width for Male and Female Callinectes amnicola*

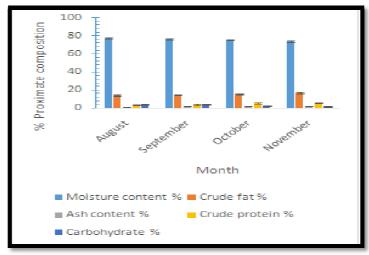*Figure 13: Percent Proximate Composition of Male Callinectes amnicola*

Figure 14: Percent Proximate Composition of Female Callinectes amnicola